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STORM WATER MANAGEMENT PLAN

TM 5350
LOG NO. 03-02-070
CALAVO 6 UNIT SUBDIVISION
CALAVO ROAD
FALLBROOK, CALIFORNIA

Prepared For:
THOMAS BUILDERS
C/O MR, TOM RABUCHIN
3875 PEONY DRIVE
FALLBROOK, CALIFORNIA 92028

Prepared By:
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(Revise) September 7, 2006
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(Revised) August 16, 2005

CTE Job No. 10-5914C

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INTRODUCTION

The Storm Water Management Plan (SWMP) is required under the County of San Diego Watershed Protection, Stormwater Management, and Discharge Control Ordinance (section 67.817). The purpose of the SWMP is to address the water quality impacts from the proposed tentative map for Calavo Road 6-Unit Subdivision. Best Management Practices (BMPs) will be utilized to provide long-term solutions to water quality. The SWMP is also intended to ensure the effectiveness of the BMPs through proper maintenance that is based on long term fiscal planning. The SWMP is subject to revisions as needed by the engineer.

1.0 PROJECT DESCRIPTION

The Calavo Road 6-Unit Subdivision (TM 5350) will consist of the construction of six detached single-family residential structures and a connector street with a cul-de-sac. All necessary utilities and drainage structures shall also be constructed. The parcels are zoned, as Rural Residential and each parcel size will be a minimum of 0.5 acres. The total site area is about 3.8 acres.

1.1 Topography and Land Use

The site has a reverse L shape to it. It is about 420 feet wide at its southern edge and 510 feet across at the eastern edge. The topography of the site is dictated by a moderately steep hill on which the project is located. The summit of the hill is located offsite northwest of the site and generally slopes from west to east and from north to south. The average slope is about 10 percent.

Based on information gathered from a site visit and aerial topographic photos it appears the project site was at one time used as an agricultural grove. Currently it is an undeveloped lot with heavy grasses growing on it. The project lies within a residential area with residential developments surrounding the project to all sites. Calavo Road borders the project site to the west.

1.2 Hydrologic Unit Contribution

The Calavo Road 6-Unit Subdivision is located within the San Luis Rey Watershed and within the Bonsall HSA (903.12). Please see attachment A for location of project. The project represents less than 0.006% of the basin. Storm water runoff from the access road and the detached residences shall be conveyed to a sixteen-foot wide vegetated buffer strip, which surrounds the project. Velocity shall be reduced to pre-development levels with riprap energy dissipaters and concentrated flows shall be dispersed with the vegetated buffer strips. Water shall discharge all along the eastern and southern borders of the proposed development.

2.0 WATER QUALITY ENVIRONMENT

2.1 Beneficial Uses

The beneficial uses for the hydrological unit are included in Tables 1.1 and 1.2. These beneficial uses are as designated within the State Water Resources Control Board's San Diego Region Basin Plan.

MUN - Municipal and Domestic Supply – Includes uses of Water for community, military, or individual water supply systems included but not limited to, drinking water supply.
AGR - Agricultural Supply – Includes uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
IND – Industrial Service Supply – Includes uses if water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.
REC1 – Contact Water Recreation – Includes uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water skiing, skin and SCUBA diving, surfing, white water activities, fishing, or use of natural hot springs.
REC2 – Non-Contract Water Recreation – Includes the uses of water for recreational activities involving proximity to water, but does not normally involve body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
WARM – Warm Freshwater Habitat – Includes uses that support warm water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish or wildlife, including invertebrates.
WILD – Wildlife Habitat – Includes uses of water that support terrestrial ecosystems, including but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

RARE -Includes uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.

2.1.1 Inland Surface Waters

In the Bonsall Hydrological sub area, the closest downstream listed inland surface water from the proposed subdivision is the San Luis Rey River. The beneficial uses for the San Luis Rey River are listed in Table 1.1.

Table 1.1 Beneficial Uses for San Luis Rey River

Hydrologic Unit Number	MUN	AGR	IND	REC1	REC2	WARM	WILD	RARE
903.13	+	*	*	*	*	*	*	*

* Existing Beneficial Use
O Potential Beneficial Use
\+ Excepted from Municipal

2.1.2 Groundwater

The general beneficial groundwater uses for the Lower San Luis Rey Hydrological Area as listed in the San Diego Regional Basin Plan are listed in Table 1.2.

Table 1.2 Beneficial uses for ground waters.

Hydrologic Unit Number	MUN	AGR	IND
903.1	*	*	*

* Existing Beneficial Use
O Potential Beneficial Use

2.2 303(d) Status

According to the California 2002 303d list published by the San Diego Regional Water Quality Control Board, no impaired bodies are directly associated with this project.

The project location and watersheds have been compared to the current published 303d list of impaired bodies and the nearest impaired water bodies are the Pacific Ocean Shoreline, which is impaired for Bacterial Indicators and the San Luis Rey River which is impaired for Chloride (lower 13 miles) and

TDS (lower 19 miles). The San Luis Rey River is about 4.7 miles south. The mouth of the Pacific Ocean Shoreline is about 17.5 miles downstream.

The anticipated pollutants from the proposed development, which has been classified as a detached residential development, includes, Sediments, Nutrients, Trash & Debris, Oxygen Demanding Substances, Oil & Grease, Bacteria & Viruses and Pesticides. Therefore, the main constituents of concern for this project include bacteria, sediment and the nutrient Phosphorus.

3.0 CHARACTERIZATION OF PROJECT RUNOFF

3.1 Existing and Post-Development Drainage

The proposed development will alter the interior drainage patterns of the site but the exterior drainage outfall locations and velocities shall remain unchanged. Total project size is 3.77 acres. About 3.51 acres of undeveloped land will be converted to single-family residential lots and an additional 0.26 acres will be paved for a total increase of approximately 15% to the impervious area. The change in land use will increase the composite runoff coefficient, of the project, from C=0.30 to C=0.45. The total peak flow rate will decrease from 12.34 cfs under the existing conditions to 11.73 cfs under the proposed condition. This decrease in peak runoff is due to the inclusion of a detention facilities.

A detailed description of the drainage patterns and flows are discussed in the hydrology and hydraulics study dated June 27, 2006. This section is an excerpt from that report. As discussed in Section 2, the existing condition is undeveloped. The existing natural environment serves as a biofilter for the runoff generated from this area.

Existing conditions is a moderately steep hillside covered with grasses and brush. Currently Stormwater runoff enters from the northwest and outfalls from the site to the south and east. Please see Table 3.1 from existing and proposed flows.

The proposed development will direct storm water runoff to the eastern and southern edge of the project. The preliminary design of the drainage system is included within the BMP map. Summaries of the post construction water quality flows are included within Table 3.1. The flows were developed from the County's standard SUSMP for the treatment of Stormwater runoff. The precipitation was found to be 0.2 in/hr/acre. Calculation are included in the aforementioned Hydrology and Hydraulics Study dated June 27, 2006.

Table 3.1 Pre and Post Development Flows and Water Quality Flows

Outfall Location	Tributary Area (acres)		Q_{100} (cfs)		Qwq (cfs) Post
	Pre	Post	Pre	Post	
1	0.05	0.06	0.11	0.14	0.02
2	2.14	2.02	5.55	5.09	1.07
3	1.00	0.95	2.11	2.09	0.44
4	1.55	1.75	4.57	4.41	0.92

3.2 Post-Construction Expected Discharge

There is no sampling data available for the existing site condition. In addition, the project is not expected to create significant amounts of these pollutants as detailed in section 2.2. Furthermore, the treatment structures shall remove pollutants to the maximum extent practicable. However, the following constituents are commonly found on similar projects and could affect water quality:

- Sediments from hills sides which either have not been properly landscaped or have been landscaped and over watering which has led to erosion;
- Nutrients from the placement of excessive fertilizers in the adjacent landscaped hillsides;
- Trash and debris from littering from passing vehicles and pedestrians;
- Petroleum hydrocarbonates from leaked fuels;
- Trash and debris from litter from passing vehicles and pedestrians;
- Oil from leaking vehicles;
- Pesticides from landscaped hillsides.

3.3 Soil Characteristics

The project area’s hydrologic soil group is considered to be ‘C’. There is expected to be many new slopes. No new slopes will be greater in slope than which is recommended by the geotechnical engineer. All slopes will include vegetative protection post-construction and appropriate construction BMPs during construction.

4.0 MITIGATION MEASURES TO PROTECT WATER QUALITY

To address water quality issues for this project, the following BMPs shall be employed during construction and for post-construction.

4.1 Construction BMPs

A detailed description of the construction BMPs will be developed during the Grading Plan and Improvement Plan Engineering. Since the project is in the preliminary development phase only a listing of potential types of temporary BMPs are available. This includes the following:

- Preservation of Existing Vegetation (SS-2)
- Hydroseeding (SS-4)
- Geotextiles, Plastic Covers & Erosion Control Blankets (SS-7)
- Silt Fence (SC-1)
- Check Dams (SC-4)
- Fiber Rolls (SC-5)
- Street Sweeping & Vacuuming (SC-7)
- Storm Drain Inlet Protection (SC-10)
- Wind Erosion Control (WE-1)
- Stabilized Construction Entrance/Exit (TC-1)
- Paving & Grinding Operations (NS-3)
- Temporary Stream Crossing (NS-4)
- Vehicle & Equipment Fueling (NS-9)
- Vehicle & Equipment Maintenance (NS-10)
- Material Delivery & Storage (WM-1)
- Stockpile Management (WM-3)
- Solid Waste Management (WM-5)
- Concrete Waste Management (WM-8)
- Sanitary/Septic Waste Management (WM-9)
- Permanent Vegetative Landscaping
- Daily Housekeeping

Construction BMPs for this project shall be placed per the SWPPP, all ordinances, and Guidance Documents. Please see the SWPPP for BMP datasheets and the grading plans erosion control sheets.

4.2 Post-construction BMPs

Pollutants of Concern as noted in Section 3 will be addressed through three types of BMPs. These types of BMP's are site design, source control and treatment control.

4.2.1 Site Design BMPs

This project is designed to minimize the use of impervious areas. The street has been designed to meet the minimum design width allowed. All slopes as shown on the BMP plan shall incorporate landscaping with appropriate vegetation and water efficient irrigation. All parking areas and decorative flatwork shall be constructed with pervious pavers whenever practical in order to reduce peak storm runoff values. Impervious areas shall not be directly connected to storm drain systems. All runoff velocities shall be reduce with the use of riprap energy dissipaters to pre development levels. Sewers shall not be connected to the storm drain system.

4.2.1.1 Permanent Landscaping & Efficient Irrigation System

Maintenance of a healthy soil structure through the practice of retaining or restoring native soils where possible and using soil amendments where appropriate can improve the land's ability to filter and slowly release storm water into drainage networks. Construction practices such as decreasing soil compaction, storing topsoil on-site for use after construction and chipping wood for mulch as it is cleared for the land can improve soil quality and help maintain healthy watersheds. Practices that reduce erosion and help retain water on-site include incorporating organic amendments into disturbed soils after construction, retaining native vegetation, and covering soil during revegetation.

Subtle changes in grading can also improve infiltration. Landscape surfaces are conventionally graded to have a slight convex slope. This causes water to run off a central high point into a surrounding drainage system, creating increased runoff. If a landscape surface is graded to have a slightly concave slope, it will hold water. The infiltration value of concave vegetated surfaces is greater in permeable soils. Soils of heavy clay or underlain with hardpan provide less infiltration value. In these cases concave vegetated surfaces must be designed as retention/detention basins, with proper outlets or under drains to an interconnected system.

Irrigation system can be designed to reduce the amount of runoff generated by taking into account the slope gradient and percolation rate of the soil. Backflow prevention units shall be installed on all potable water irrigation systems. Control systems shall be installed which efficiently control all laterals and areas to deliver the amounts of irrigation required.

4.2.1.2 Riprap Energy Dissipaters

At all locations where storm water shall exit the site riprap energy dissipaters shall be installed. They shall be sized appropriately and shall reduce runoff velocities to pre-development levels. Regular maintenance shall be performed in order to keep the energy dissipaters operating at top capacity.

4.2.2 Source Control BMPs

The following Source Control BMPs will be implemented to address water quality:

- Educational Program
- Signage on Storm Drain Curb Inlets

4.2.2.1 Educational Program

Source control BMPs will consist of various measures designed to prevent polluted runoff. All new adjacent homeowners shall receive a series of brochures developed by the County's Environmental Health Department. For a current list of applicable brochures please contact the County. In addition, information shall be supplied to new homeowners regarding the closest household waste disposal site, which is the City of Vista's Household Hazardous Waste Disposal Facility located at 1145 E. Taylor Street, Vista California.

4.2.2.2 Signage on Storm Drain Curb Inlet

At the drop inlets located along the proposed access road trash catching screens will be installed these screens will prevent litter and debris from entering into the detention facilities and clogging them. The screens will need to be cleaned on a regular basis. Screens shall be sized to protect the entire inlet. They will be designed to allow overflow in case of high flows and or clogging in order to prevent flooding.

4.2.3 Treatment Control BMPs

The following treatment control BMPs will be implemented to address water quality:

- Vegetated Buffer Strip(TC-31)
- Vegetated Swale (TC-30)
- Detention Facility(TC-22)
- Trash Catcher Grate(MP-52)

4.2.3.1 Vegetated Buffer Strip

They are grassed buffer strips that are designed to treat flow from an adjacent surface. The vegetated buffer strip works by slowing runoff velocities and allowing sediment and other pollutants to settle by allowing some infiltration into underlying soils. With proper design and maintenance, they can provide relatively high pollutant removal.

Vegetated buffer strips provide a number of advantages over other more complex systems. Strips need only a minimum of maintenance. Usually they only need to be mowed as often as needed for appearance however inspections should be at least twice a year. Vegetated buffer strips are among the most visually appealing of all BMPs, if properly designed. Flow characteristics may be easily controlled by vegetation type and density. Maintenance does not require any special maintenance skills or training.

If the vegetation is not maintained or burrowing vermin are allowed to infest the vegetated buffer strip will looses their effectiveness. Periodically litter and debris must be removed by hand. Buffer strips are not effective for very intense rainfall events. Vegetated buffer strips do not provide significant treatment for dissolved pollutants except for that, which is infiltrated into the soil.

4.2.3.2 Vegetated Swales

Vegetated swales will be employed as indicated on the grading plans and the Post-Construction BMP Map (Attachment C). Details are on the tentative map grading plan.

Vegetated swales are open shallow channels, which have vegetation covering the sides and bottoms. They collect and slowly discharge storm water runoff. They are designed to treat runoff through filtration in the vegetation and infiltration through the subsoil matrix. Flow may be easily controlled by vegetation type and density. Vegetated swales provide good treatment levels for relatively small (85^{th} %) storms but are less effective for larger storms.

Vegetated swales should be inspected and maintained as indicated in section 5.4. Financial responsibility for maintenance of the vegetated swales will be born by the individual homeowners as detailed in section 6.5.

4.2.3.3 Detention Basin

Detention Basins are basins whose outlets have been designed to detain the runoff. The facilities will consist of underground pipes. The pipe design was chosen due to lack of space and safety and vector concerns with it being within a residential area. Because the pipe is PVC much of the treatment ability is lost. The detention facilities were sized to perform flood control for peak runoffs. By reducing peak runoffs from a site they provide benefits which include; reducing downstream erosion, habitat destruction and potential flooding of property. Because it reduces downstream erosion it also helps to fight downstream siltation as the eroded channels are deposited. Please see the Post-Construction BMP Map (Attachment C) for location of the detention pipes. See section 5.5

for maintenance and inspection requirements and section 6.6 for financial responsibilities.

4.2.3.4 Trash Catcher Grates

At the drop inlets located along the proposed access road trash catching screens will be installed. These screens will prevent litter and debris from entering into the detention facilities and clogging them. As long as they are maintained trash catcher grates are very effective in removing trash and debris from storm water runoff. Please see the Post-Construction BMP Map (Attachment C) for location of the trash catcher screens. See section 5.6 for maintenance and inspection requirements and section 6.7 for financial responsibilities.

5.0 OPERATIONS AND MAINTENANCE PROGRAM

The operation and maintenance requirements for each type of BMP are described below. Debris, trash, and sediment disposal shall be the responsibility of the owner as listed in Section 6.0. All trash, debris, and sediment shall be disposed in a proper manner.

5.1 Permanent Landscaping and Efficient Irrigation

Maintenance Requirements:
Litter shall be removed, broken or malfunctioning irrigation pipes or equipment shall be repaired, and landscape shall be fertilized/cared for as required.

Maintenance Frequency:
Landscaped slopes and irrigation shall be maintained on a bi-weekly basis minimum.

Financial Responsibility
Individual homeowners shall be responsible for their individual properties. See section 6.0 for fiscal resources.

5.2 Riprap Energy Dissipaters

Maintenance Requirements:
Any damage to energy dissipaters shall be repaired as soon as it is safe to do so. Vegetation shall be trimmed and or removed as necessary. As necessary blockages and silt buildup shall be removed.

Maintenance Frequency:
Maintenance shall be performed when necessary as dictated by inspections. Inspections shall be performed on a regular basis, at least three times a year and after all major storm events.

Financial Responsibility
All riprap is located within areas that will be maintained by the homeowners. See section 6.0 for fiscal resources.

5.3 Vegetated Buffer Strip

Maintenance Requirements:
Litter and weeds shall be removed and grass shall be mowed on a scheduled basis. Any vermin shall be removed and damage repaired.

Maintenance Frequency:
Maintenance shall be on a regularly scheduled basis, usual to coincide with regular landscaping, but should also occur after all major storm events.

Financial Responsibility
The vegetated buffer strips will be located within areas that will be maintained by the homeowners. See section 6.0 for fiscal resources.

5.4 Vegetated Swales

Maintenance Requirements:
Vegetated Swales require maintenance similar to landscaping. The maintenance requirements include weeding, fertilization, trash pick up, mowing, and irrigation. In addition to these requirements maintenance shall also include cleaning out accumulated silt and debris after storm events.

Maintenance Frequency:
Maintenance shall be performed when necessary as dictated by inspections. Inspections shall be performed on a regular basis, at least three times a year and after all major storm events.

Financial Responsibility
The vegetated swales shall be located on individual homeowner’s property and shall be the responsibility of the homeowner to maintain. See section 6.0 for fiscal resources.

5.5 Detention Basin

Maintenance Requirements:
Special care should be taken to ensure that the control release orifices do not become clogged. Said maintenance will usual consist of removal of trash, sediment and organic debris.

Maintenance Frequency:
Maintenance should be performed on a semi annual basis. Further maintenance may be necessary if monthly inspections during the rainy season reveal additional requirements.

Financial Responsibility
The detention basin will be located within each homeowner's property. They will be maintained by the homeowner. See section 6.0 for fiscal resources.

5.6 Trash Catcher Grates

Maintenance Requirements:
Trash and debris should be removed on a regular basis. Any damage should be repaired.

Maintenance Frequency:
Maintenance should be performed on a regular basis. Maintenance may be necessary if regular inspections reveal additional maintenance requirements.

Financial Responsibility
The trash catchers will be located within each homeowner's property. They will be maintained by the homeowner. See section 6.0 for fiscal resources.

6.0 FISCAL RESOURCES

6.1 Project Owner

The Owner of this Project is:
THOMAS BUILDERS
C/O MR, TOM RABUCHIN
3875 PEONY DRIVE
FALLBROOK, CALIFORNIA 92028

The landscaping and efficient irrigation are considered part of the site design and are not “treatment control” BMPs. Maintenance of these items shall be performed as part of the regular maintenance by the homeowners.

All permanent post-construction BMPs, including vegetated swales, vegetated buffer strip, detention basin and trash grates shall be considered maintenance category one. All category one BMPs are located within the private homeowners properties and will be the responsibility of the private homeowners. At completion of the project the private homeowners take over responsibility for maintenance of all BMPs from the developer. The private homeowners will be responsible for financing all maintenance required by the BMPs. Because all BMPs on this project are considered category one no bonding will be necessary because all maintenance will be performed as part of the normal site maintenance.

The San Diego County Water Pollution Ordinance requires ongoing maintenance of all post construction treatment control BMPs. Under the WPO (water pollution ordinance) failure to maintain a BMP would constitute a public nuisance which may be abated by the County. This allows the County to bill the responsible party for costs of abatement. In addition, the WPO allows for civil actions, criminal actions and administrative citations for violation of the ordinance.

Section 67.819(e) of the WPO requires developers to provide clear written notice to person(s) acquiring land with BMPs or assuming maintenance obligations of their maintenance duty. For applications whose approval ongoing conditions may be imposed, a condition will be added which requires the owner of the land in which the treatment control BMP is located to maintain per required specifications (maintenance agreement).

Approval of the tentative map will be conditioned to require that prior to approval of the final or parcel map the developer shall provide to the director of public works, that the developer has requested the California Department of Real Estate to include within the public report to be issued for the sales of the lot within the subdivision a notification regarding the maintenance agreement. If no public report will be issued or the subdivision is found to be exempt this requirement shall be null.

6.2 Landscaping and Irrigation

Landscaping and irrigation will be the responsibility of the private homeowners. They are expected to perform all maintenance activities as part of the regular landscaping duties. They are not considered treatment control BMPs. Maintenance will be performed per section 5.1.

6.3 Riprap Energy Dissipaters

Riprap Energy dissipaters are located at six points. For exact locations please see the attached Post Construction BMP Maps (Attachment C). Riprap energy dissipaters will be the responsibility of the private homeowners. They are expected to perform all maintenance activities are part of the regular duties. They are not considered treatment control BMPs. Maintenance will be performed per section 5.2.

6.4 Vegetated Buffer Strip

The vegetated buffer strip is a category one BMP and is located at the southern and eastern edges of the proposed development. For exact locations, please see the attached Post Construction BMP Maps (Attachment C). Maintaining the vegetated buffer strip will be the responsibility of the private homeowners. They are expected to perform all maintenance activities as part of the regular landscaping duties. Maintenance shall be performed per section 5.3.

6.5 Vegetated Swale

Vegetated swales that are located along the perimeter of the pads and are considered category one BMPs. For exact locations please see the BMP Map (Attachment C). The maintenance shall be the responsibility of the individual homeowners. They are expected to perform all maintenance activities as part of the regular landscaping duties. Maintenance shall be performed per Section 5.4.

6.6 Detention Basin

Peak storm water runoff shall be detained through the use of a small detention facilities that will be located within each homeowner’s property. They are considered category one BMPs and shall be maintained by the individual homeowners. For exact locations please see the BMP Map (Attachment C). Maintenance shall be performed per Section 5.5.

6.7 Trash Catcher Grates

Trash catcher grates shall be located within the right of way of the access road for the proposed lots. Because this is a private road the trash catcher grate maintenance will be the responsibility of the individual homeowners of which properties the grates are located. Trash catcher grates are considered category one BMPs. For exact locations please see the BMP Map (Attachment C). It is located within the public maintenance easement and shall be the responsibility of the storm water maintenance zone. Maintenance shall be performed per Section 5.6.

7.0 SUMMARY/CONCLUSION

This SWMP has been prepared in accordance with the Watershed Protection, Stormwater Management, and Discharge Control Ordinance and the Stormwater Standards Manual. This SWMP has evaluated and addressed the potential pollutants associated with this project and their effects on water quality. A summary of the facts and findings associated with this project and the measures addressed by this SWMP are as follows:

The beneficial uses for the receiving waters have been identified. None of these beneficial uses will be impaired or diminished due to the construction or maintenance of this project.

The project will not significantly alter the drainage pattern of the project site. The project will continue to discharge towards the existing outfall locations.

The site has been designed to reduce the amount of impermeable surface to the least amount feasible.

Education, awareness programs, and stenciling shall be used to inform residents of storm water requirements.

The proposed construction and post construction BMPs address mitigation measures to protect water quality and protection of water quality objectives and beneficial uses to the maximum extent practicable.

The combination of proposed construction and post-construction BMPs will reduce, to the maximum extent practicable, the expected pollutants and will not adversely impact the beneficial uses of water quality of the receiving waters.

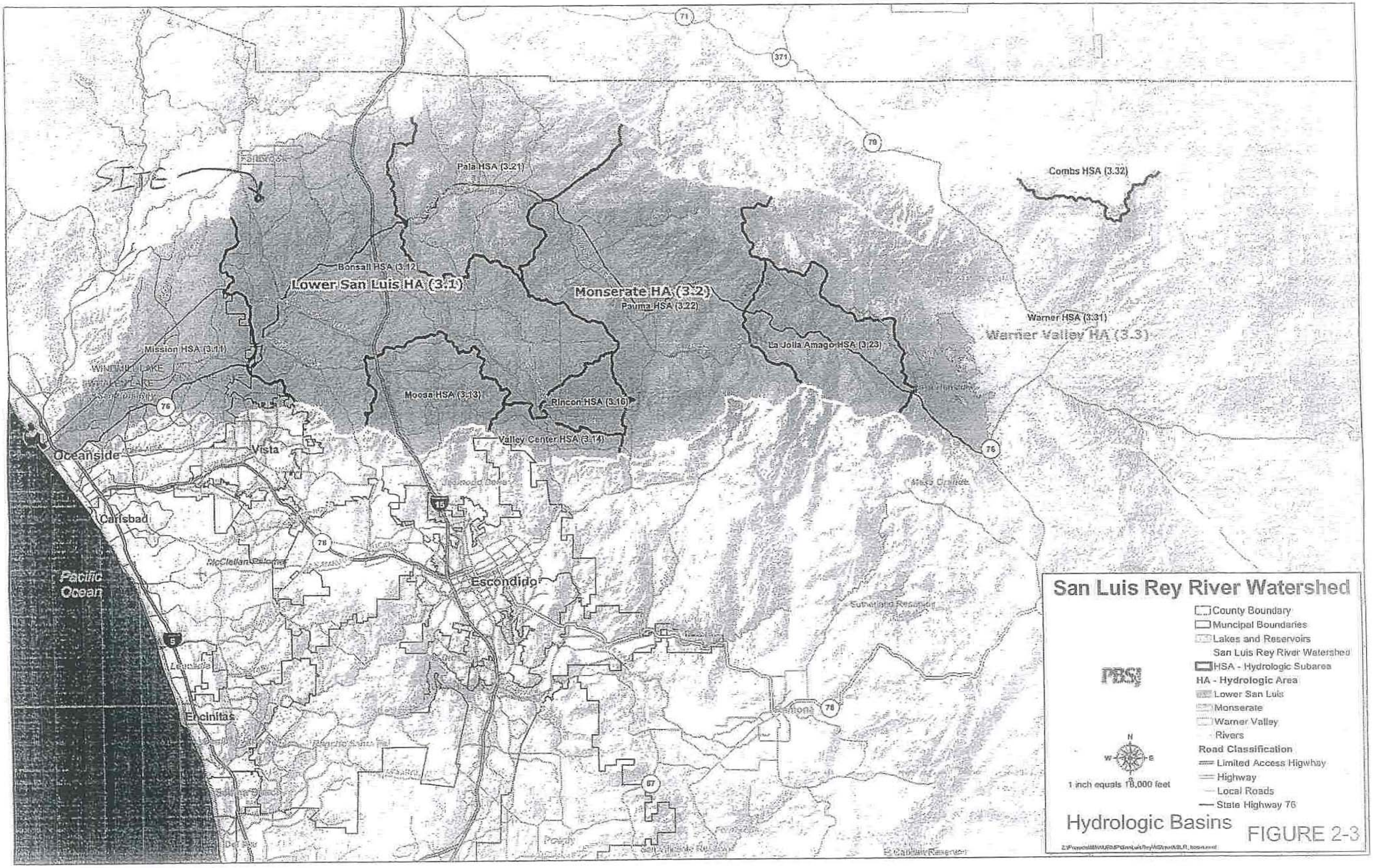
This Storm Water Management Plan has been prepared under the direction of Rodney D. Ballard, a Registered Civil Engineer. Mr. Ballard attests to the technical information contained herein and the engineering data upon which recommendations, conclusions, and decisions are based.

Rodney D. Ballard
RCE 043345

9/7/06
Date

ATTACHMENT A

LOCATION MAP



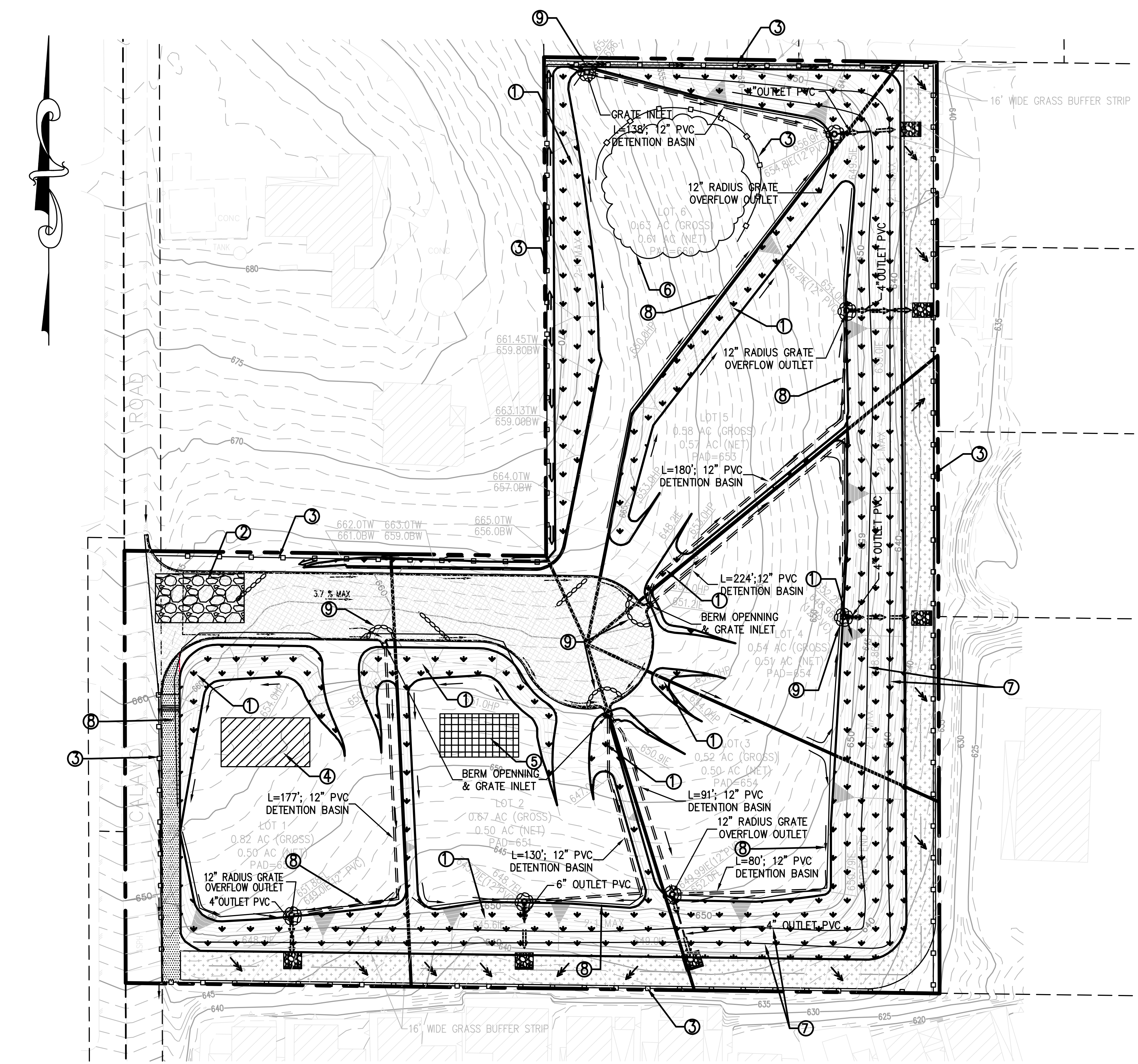
San Luis Rey River Watershed

Hydrologic Basins

FIGURE 2-3

ATTACHMENT B

EROSION CONTROL MAP



LEGEND

- DIRECTION OF FLOW
- BROW DITCH
- SWALE FLOW
- GRASS-LINED SWALE
- 656.43 SPOT ELEVATION
- 650 EXISTING CONTOUR (MAJOR)
- EXISTING CONTOUR (MINOR)
- 650 PROPOSED CONTOUR (MAJOR)
- PROPOSED CONTOUR (MINOR)
- DAYLIGHT LINE
- 2:1 CUT/2:1 FILL SLOPE

EROSION CONTROL BMPS

1. HYDROSEEDED SLOPES
2. CONSTRUCTION ENTRANCE
3. SILT FENCE
4. CONCRETE / HAZARD WASTESITE
5. SANITATION / STORAGE SITE
6. STOCK PILE AREA
7. FIBER ROLL
8. TOP OF SLOPE BERM & SWALE/GRAVEL BAGS
9. GRAVEL BAGS AROUND INLETS

GRAPHIC SCALE

60' 0 30' 60' 120' 240'

1 inch = 60' ft.

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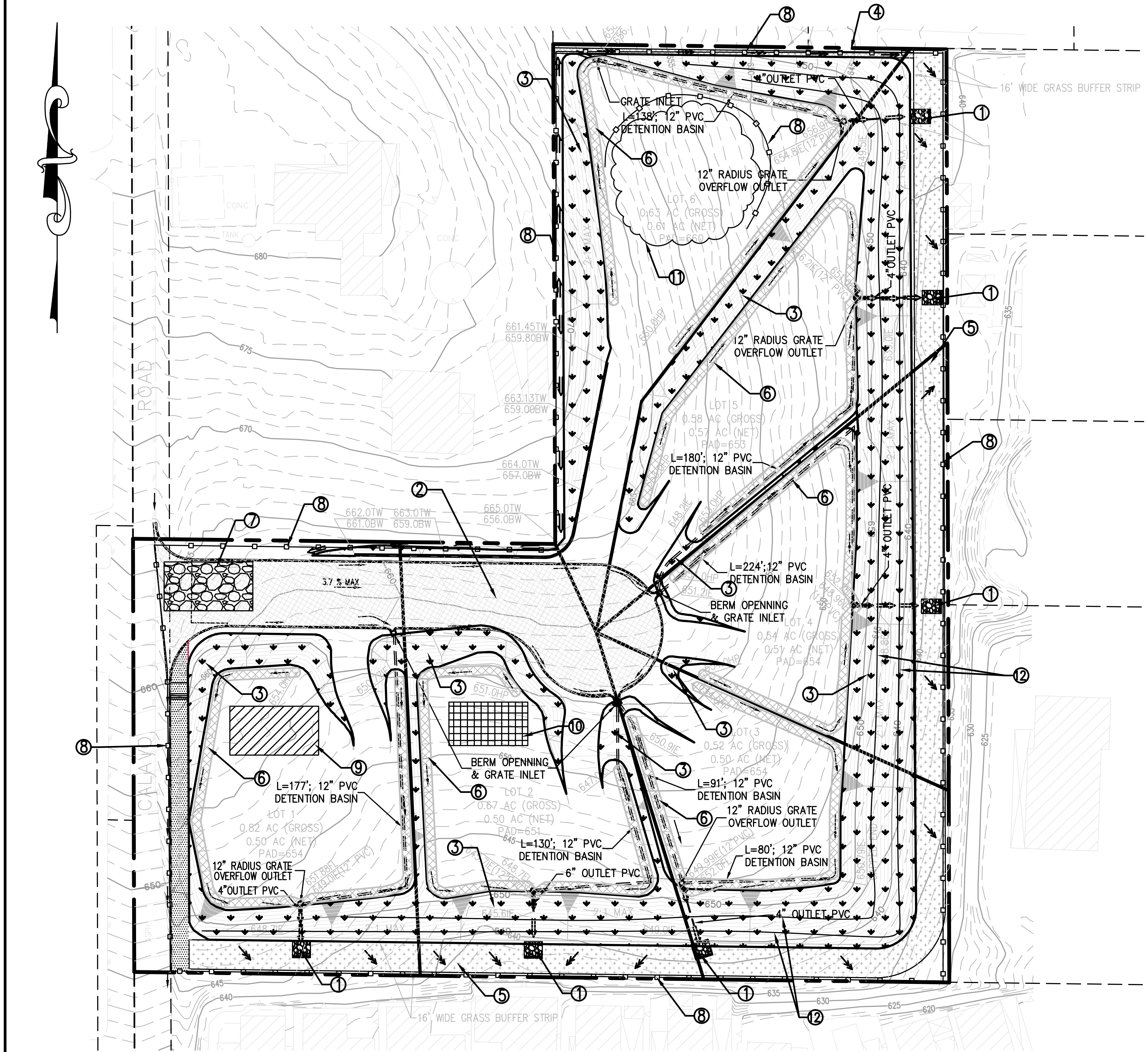
EROSION CONTROL PLAN
CALAVO 6 UNIT SUBDIVISION
TM 5350
FALLBROOK, CALIFORNIA

CTE JOB NO:	10-5914C
SCALE:	1"=60'
DATE: 6/28/06	ATTACHMENT: B

\\Engineering\E\Land Projects 2005\10-5914c\dwg\SWMP\5914EC.dwg 9/7/2006 10:08:46 AM PDT

ATTACHMENT C

BMP MAP



LEGEND

DIRECTION OF FLOW
BROW DITCH
SWALE FLOW
GRASS-LINED SWALE
656.43 SPOT ELEVATION
650 EXISTING CONTOUR (MAJOR)
EXISTING CONTOUR (MINOR)
650 PROPOSED CONTOUR (MAJOR)
PROPOSED CONTOUR (MINOR)
DAYLIGHT LINE
2:1 CUT/2:1 FILL SLOPE

POST-CONSTRUCTION BMPS

1. RIP-RAP ENERGY DISSIPATOR
2. PAVEMENT
3. LANDSCAPED SLOPES
4. GRASS-LINED DRAINAGE DITCH
5. VEGETATED BUFFER STRIP
6. VEGETATED SWALE
7. CONSTRUCTION ENTRANCE
8. SILT FENCE
9. CONCRETE / HAZARD WASTESITE
10. SANITATION / STORAGE SITE
11. STOCK PILE AREA
12. FIBER ROLL

GRAPHIC SCALE

60' 0 30' 60' 120' 240'

1 inch = 60' ft.

CONSTRUCTION TESTING & ENGINEERING, INC.
PLANNING - CIVIL ENGINEERING - LAND SURVEYING - GEOTECHNICAL
1441 MONTIEL ROAD, SUITE 115 ESCONDIDO CA. 92026, PH:(760) 746-4955

PRE & POST CONSTRUCTION BMP PLAN
CALAVO 6 UNIT SUBDIVISION
TM 5350
FALLBROOK, CALIFORNIA

CTE JOB NO:	10-5914C
SCALE:	1"=60'
DATE: 6/28/06	ATTACHMENT: C

\\Engineering\E\Land Projects 2005\10-5914c\dwg\SWMP\5914BMPPlan.dwg 9/7/2006 10:15:19 AM PDT

ATTACHMENT D

POST CONSTRUCTION BMPS DATA SHEETS

Extended Detention Basin TC-22

Design Considerations

- Tributary Area
- Area Required
- Hydraulic Head

Description

Dry extended detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

California Experience

Caltrans constructed and monitored 5 extended detention basins in southern California with design drain times of 72 hours. Four of the basins were earthen, less costly and had substantially better load reduction because of infiltration that occurred, than the concrete basin. The Caltrans study reaffirmed the flexibility and performance of this conventional technology. The small headloss and few siting constraints suggest that these devices are one of the most applicable technologies for stormwater treatment.

Advantages

- Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate.
- Extended detention basins can provide substantial capture of sediment and the toxics fraction associated with particulates.
- Widespread application with sufficient capture volume can provide significant control of channel erosion and enlargement caused by changes to flow frequency relationships resulting from the increase of impervious cover in a watershed.

Targeted Constituents

✓	Sediment	▲
✓	Nutrients	●
✓	Trash	■
✓	Metals	▲
✓	Bacteria	▲
✓	Oil and Grease	▲
✓	Organics	▲

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

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Limitations

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).

- Dry extended detention ponds have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.

- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home due to the adverse aesthetics of dry, bare areas and inlet and outlet structures.

Design and Sizing Guidelines

- Capture volume determined by local requirements or sized to treat 85% of the annual runoff volume.

- Outlet designed to discharge the capture volume over a period of hours.

- Length to width ratio of at least 1.5:1 where feasible.

- Basin depths optimally range from 2 to 5 feet.

- Include energy dissipation in the inlet design to reduce resuspension of accumulated sediment.

- A maintenance ramp and perimeter access should be included in the design to facilitate access to the basin for maintenance activities and for vector surveillance and control.

- Use a draw down time of 48 hours in most areas of California. Draw down times in excess of 48 hours may result in vector breeding, and should be used only after coordination with local vector control authorities. Draw down times of less than 48 hours should be limited to BMP drainage areas with coarse soils that readily settle and to watersheds where warming may be determined to downstream fisheries.

Construction/Inspection Considerations

- Inspect facility after first large to storm to determine whether the desired residence time has been achieved.

- When constructed with small tributary area, orifice sizing is critical and inspection should verify that flow through additional openings such as bolt holes does not occur.

Performance

One objective of stormwater management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most detention ponds.

Dry extended detention basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Several studies are available on the effectiveness of dry extended detention ponds including one recently concluded by Caltrans (2002).

The load reduction is greater than the concentration reduction because of the substantial infiltration that occurs. Although the infiltration of stormwater is clearly beneficial to surface receiving waters, there is the potential for groundwater contamination. Previous research on the effects of incidental infiltration on groundwater quality indicated that the risk of contamination is minimal.

There were substantial differences in the amount of infiltration that were observed in the earthen basins during the Caltrans study. On average, approximately 40 percent of the runoff entering the unlined basins infiltrated and was not discharged. The percentage ranged from a high of about 60 percent to a low of only about 8 percent for the different facilities. Climatic conditions and local water table elevation are likely the principal causes of this difference. The least infiltration occurred at a site located on the coast where humidity is higher and the basin invert is within a few meters of sea level. Conversely, the most infiltration occurred at a facility located well inland in Los Angeles County where the climate is much warmer and the humidity is less, resulting in lower soil moisture content in the basin floor at the beginning of storms.

Vegetated detention basins appear to have greater pollutant removal than concrete basins. In the Caltrans study, the concrete basin exported sediment and associated pollutants during a number of storms. Export was not as common in the earthen basins, where the vegetation appeared to help stabilize the retained sediment.

Siting Criteria

Dry extended detention ponds are among the most widely applicable stormwater management practices and are especially useful in retrofit situations where their low hydraulic head requirements allow them to be sited within the constraints of the existing storm drain system. In addition, many communities have detention basins designed for flood control. It is possible to modify these facilities to incorporate features that provide water quality treatment and/or channel protection. Although dry extended detention ponds can be applied rather broadly, designers need to ensure that they are feasible at the site in question. This section provides basic guidelines for siting dry extended detention ponds.

In general, dry extended detention ponds should be used on sites with a minimum area of 5 acres. With this size catchment area, the orifice size can be on the order of 0.5 inches. On smaller sites, it can be challenging to provide channel or water quality control because the orifice diameter at the outlet needed to control relatively small storms becomes very small and thus prone to clogging. In addition, it is generally more cost-effective to control larger drainage areas due to the economies of scale.

Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds may need an impermeable liner to prevent ground water contamination.

The base of the extended detention facility should not intersect the water table. A permanently wet bottom may become a mosquito breeding ground. Research in Southwest Florida (Santana et al., 1994) demonstrated that intermittently flooded systems, such as dry extended detention ponds, produce more mosquitoes than other pond systems, particularly when the facilities remained wet for more than 3 days following heavy rainfall.

A study in Prince George's County, Maryland, found that stormwater management practices can increase stream temperatures (Galli, 1990). Overall, dry extended detention ponds increased temperature by about 5°F. In cold water streams, dry ponds should be designed to detain stormwater for a relatively short time (i.e., 24 hours) to minimize the amount of warming that occurs in the basin.

Additional Design Guidelines

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be sized appropriately. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the design of the basin should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al., 1996).

Energy dissipation structures should be included for the basin inlet to prevent resuspension of accumulated sediment. The use of stilling basins for this purpose should be avoided because the standing water provides a breeding area for mosquitoes.

Extended detention facilities should be sized to completely capture the water quality volume. A micropool is often recommended for inclusion in the design and one is shown in the schematic diagram. These small permanent pools greatly increase the potential for mosquito breeding and complicate maintenance activities; consequently, they are not recommended for use in California.

A large aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W) where feasible. Basin depths optimally range from 2 to 5 feet.

Figure 1
Example of Extended Detention Outlet Structure

The facility's drawdown time should be regulated by an orifice or weir. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. The outlet design implemented by Caltrans in the facilities constructed in San Diego County used an outlet riser with orifices sized to discharge the water quality volume, and the riser overflow height was set to the design storm elevation. A stainless steel screen was placed around the outlet riser to ensure that the orifices would not become clogged with debris. Sites either used a separate riser or broad crested weir for overflow of runoff for the 25 and greater year storms. A picture of a typical outlet is presented in Figure 1.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure can be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed.

Summary of Design Recommendations

(1) Facility Sizing - The required water quality volume is determined by local regulations or the basin should be sized to capture and treat 85% of the annual runoff volume. See Section 5.5.1 of the handbook for a discussion of volume-based design.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flowpath length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from 100-year storm.

(2) Pond Side Slopes - Side slopes of the pond should be 3:1 (H:V) or flatter for grass stabilized slopes. Slopes steeper than 3:1 (H:V) must be stabilized with an appropriate slope stabilization practice.

(3) Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility.

(4) Basin Inlet – Energy dissipation is required at the basin inlet to reduce resuspension of accumulated sediment and to reduce the tendency for short-circuiting.

(5) Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2gH-H_o)^{0.5}$$

where:
Q = discharge (ft^3/s)
C = orifice coefficient
A = area of the orifice (ft^2)
g = gravitational constant (32.2)
H = water surface elevation (ft)
H_o= orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter. This equation can be implemented in spreadsheet form with the pond stage/volume relationship to calculate drain time. To do this, use the initial height of the water above the orifice for the water quality volume. Calculate the discharge and assume that it remains constant for approximately 10 minutes. Based on that discharge, estimate the total discharge during that interval and the new elevation based on the stage volume relationship. Continue to iterate until H is approximately equal to H_o. When using multiple orifices the discharge from each is summed.

(6) Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume. The splitter box, or other flow diverting approach, should be designed to convey the 25-year storm event while providing at least 1.0 foot of freeboard along pond side slopes.

(7) Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.

(8) Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

Maintenance

Routine maintenance activity is often thought to consist mostly of sediment and trash and debris removal; however, these activities often constitute only a small fraction of the maintenance hours. During a recent study by Caltrans, 72 hours of maintenance was performed annually, but only a little over 7 hours was spent on sediment and trash removal. The largest recurring activity was vegetation management, routine mowing. The largest absolute number of hours was associated with vector control because of mosquito breeding that occurred in the stilling basins (example of standing water to be avoided) installed as energy dissipaters. In most cases, basic housekeeping practices such as removal of debris accumulations and vegetation management to ensure that the basin dewaters completely in 48-72 hours is sufficient to prevent creating mosquito and other vector habitats.

Consequently, maintenance costs should be estimated based primarily on the mowing frequency and the time required. Mowing should be done at least annually to avoid establishment of woody vegetation, but may need to be performed much more frequently if aesthetics are an important consideration.

Typical activities and frequencies include:

- Schedule semiannual inspection for the beginning and end of the wet season for standing water, slope stability, sediment accumulation, trash and debris, and presence of burrows.
- Remove accumulated trash and debris in the basin and around the riser pipe during the semiannual inspections. The frequency of this activity may be altered to meet specific site conditions.
- Trim vegetation at the beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and vector reasons.
- Remove accumulated sediment and regrade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume. Inspect the basin each year for accumulated sediment volume.

Cost

Construction Cost

The construction costs associated with extended detention basins vary considerably. One recent study evaluated the cost of all pond systems (Brown and Schueler, 1997). Adjusting for inflation, the cost of dry extended detention ponds can be estimated with the equation:

$$C = 12.4V^{0.760}$$

where: C = Construction, design, and permitting cost, and
V = Volume (ft^3).

Using this equation, typical construction costs are:

$ 41,600 for a 1 acre-foot pond

$ 239,000 for a 10 acre-foot pond

$ 1,380,000 for a 100 acre-foot pond

Interestingly, these costs are generally slightly higher than the predicted cost of wet ponds (according to Brown and Schueler, 1997) on a cost per total volume basis, which highlights the difficulty of developing reasonably accurate construction estimates. In addition, a typical facility constructed by Caltrans cost about $160,000 with a capture volume of only 0.3 ac-ft.

An economic concern associated with dry ponds is that they might detract slightly from the value of adjacent properties. One study found that dry ponds can actually detract from the perceived value of homes adjacent to a dry pond by between 3 and 10 percent (Emmerling-Dinovo, 1995).

Maintenance Cost

For ponds, the annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost (EPA website). Alternatively, a community can estimate the cost of the maintenance activities outlined in the maintenance section. Table 1 presents the maintenance costs estimated by Caltrans based on their experience with five basins located in southern California. Again, it should be emphasized that the vast majority of hours are related to vegetation management (mowing).

Table 1 Estimated Average Annual Maintenance Effort

Activity	Labor Hours	Equipment & Material ($)	Cost
Inspections	4	7	183
Maintenance	49	126	2282
Vector Control	0	0	0
Administration	3	0	132
Materials	-	535	535
Total	**56**	**$668**	**$3,132**

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Design Considerations

- Tributary Area
- Area Required
- Slope
- Water Availability

Description

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. They trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff. Vegetated swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

California Experience

Caltrans constructed and monitored six vegetated swales in southern California. These swales were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- If properly designed, vegetated, and operated, swales can serve as an aesthetic, potentially inexpensive urban development or roadway drainage conveyance measure with significant collateral water quality benefits.

Targeted Constituents

✓	Sediment	▲
✓	Nutrients	●
✓	Trash	●
✓	Metals	▲
✓	Bacteria	●
✓	Oil and Grease	▲
✓	Organics	▲

Legend ***(Removal Effectiveness)***

● Low ■ High

▲ Medium

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- Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible.

Limitations

- Can be difficult to avoid channelization.
- May not be appropriate for industrial sites or locations where spills may occur
- Grassed swales cannot treat a very large drainage area. Large areas may be divided and treated using multiple swales.
- A thick vegetative cover is needed for these practices to function properly.
- They are impractical in areas with steep topography.
- They are not effective and may even erode when flow velocities are high, if the grass cover is not properly maintained.
- In some places, their use is restricted by law: many local municipalities require curb and gutter systems in residential areas.
- Swales are mores susceptible to failure if not properly maintained than other treatment BMPs.

Design and Sizing Guidelines

- Flow rate based design determined by local requirements or sized so that 85% of the annual runoff volume is discharged at less than the design rainfall intensity.
- Swale should be designed so that the water level does not exceed 2/3rds the height of the grass or 4 inches, which ever is less, at the design treatment rate.
- Longitudinal slopes should not exceed 2.5%
- Trapezoidal channels are normally recommended but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- Swales constructed in cut are preferred, or in fill areas that are far enough from an adjacent slope to minimize the potential for gopher damage. Do not use side slopes constructed of fill, which are prone to structural damage by gophers and other burrowing animals.
- A diverse selection of low growing, plants that thrive under the specific site, climatic, and watering conditions should be specified. Vegetation whose growing season corresponds to the wet season are preferred. Drought tolerant vegetation should be considered especially for swales that are not part of a regularly irrigated landscaped area.
- The width of the swale should be determined using Manning's Equation using a value of 0.25 for Manning's n.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.

- Install swales at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be used.

- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the swale or strip.

- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

The literature suggests that vegetated swales represent a practical and potentially effective technique for controlling urban runoff quality. While limited quantitative performance data exists for vegetated swales, it is known that check dams, slight slopes, permeable soils, dense grass cover, increased contact time, and small storm events all contribute to successful pollutant removal by the swale system. Factors decreasing the effectiveness of swales include compacted soils, short runoff contact time, large storm events, frozen ground, short grass heights, steep slopes, and high runoff velocities and discharge rates.

Conventional vegetated swale designs have achieved mixed results in removing particulate pollutants. A study performed by the Nationwide Urban Runoff Program (NURP) monitored three grass swales in the Washington, D.C., area and found no significant improvement in urban runoff quality for the pollutants analyzed. However, the weak performance of these swales was attributed to the high flow velocities in the swales, soil compaction, steep slopes, and short grass height.

Another project in Durham, NC, monitored the performance of a carefully designed artificial swale that received runoff from a commercial parking lot. The project tracked 11 storms and concluded that particulate concentrations of heavy metals (Cu, Pb, Zn, and Cd) were reduced by approximately 50 percent. However, the swale proved largely ineffective for removing soluble nutrients.

The effectiveness of vegetated swales can be enhanced by adding check dams at approximately 17 meter (50 foot) increments along their length (See Figure 1). These dams maximize the retention time within the swale, decrease flow velocities, and promote particulate settling. Finally, the incorporation of vegetated filter strips parallel to the top of the channel banks can help to treat sheet flows entering the swale.

Only 9 studies have been conducted on all grassed channels designed for water quality (Table 1). The data suggest relatively high removal rates for some pollutants, but negative removals for some bacteria, and fair performance for phosphorus.

Table 1 Grassed swale pollutant removal efficiency data

	Removal Efficiencies (% Removal)						
Study	TSS	TP	TN	NO_3	Metals	Bacteria	Type
Caltrans 2002	77	8	67	66	83-90	-33	dry swales
Goldberg 1993	67.8	4.5	-	31.4	42–62	-100	grassed channel
Seattle Metro and Washington Department of Ecology 1992	60	45	-	-25	2–16	-25	grassed channel
Seattle Metro and Washington Department of Ecology, 1992	83	29	-	-25	46–73	-25	grassed channel
Wang et al., 1981	80	-	-	-	70–80	-	dry swale
Dorman et al., 1989	98	18	-	45	37–81	-	dry swale
Harper, 1988	87	83	84	80	88–90	-	dry swale
Kercher et al., 1983	99	99	99	99	99	-	dry swale
Harper, 1988.	81	17	40	52	37–69	-	wet swale
Koon, 1995	67	39	-	9	-35 to 6	-	wet swale

While it is difficult to distinguish between different designs based on the small amount of available data, grassed channels generally have poorer removal rates than wet and dry swales, although some swales appear to export soluble phosphorus (Harper, 1988; Koon, 1995). It is not clear why swales export bacteria. One explanation is that bacteria thrive in the warm swale soils.

Siting Criteria

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system (Schueler et al., 1992). In general, swales can be used to serve areas of less than 10 acres, with slopes no greater than 5 %. Use of natural topographic lows is encouraged and natural drainage courses should be regarded as significant local resources to be kept in use (Young et al., 1996).

Selection Criteria (NCTCOG, 1993)

- Comparable performance to wet basins
- Limited to treating a few acres
- Availability of water during dry periods to maintain vegetation
- Sufficient available land area

Research in the Austin area indicates that vegetated controls are effective at removing pollutants even when dormant. Therefore, irrigation is not required to maintain growth during dry periods, but may be necessary only to prevent the vegetation from dying.

The topography of the site should permit the design of a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

Additional Design Guidelines

Most of the design guidelines adopted for swale design specify a minimum hydraulic residence time of 9 minutes. This criterion is based on the results of a single study conducted in Seattle, Washington (Seattle Metro and Washington Department of Ecology, 1992), and is not well supported. Analysis of the data collected in that study indicates that pollutant removal at a residence time of 5 minutes was not significantly different, although there is more variability in that data. Therefore, additional research in the design criteria for swales is needed. Substantial pollutant removal has also been observed for vegetated controls designed solely for conveyance (Barrett et al, 1998); consequently, some flexibility in the design is warranted.

Many design guidelines recommend that grass be frequently mowed to maintain dense coverage near the ground surface. Recent research (Colwell et al., 2000) has shown mowing frequency or grass height has little or no effect on pollutant removal.

Summary of Design Recommendations

1) The swale should have a length that provides a minimum hydraulic residence time of at least 10 minutes. The maximum bottom width should not exceed 10 feet unless a dividing berm is provided. The depth of flow should not exceed 2/3rds the height of the grass at the peak of the water quality design storm intensity. The channel slope should not exceed 2.5%.

2) A design grass height of 6 inches is recommended.

3) Regardless of the recommended detention time, the swale should be not less than 100 feet in length.

4) The width of the swale should be determined using Manning's Equation, at the peak of the design storm, using a Manning's n of 0.25.

5) The swale can be sized as both a treatment facility for the design storm and as a conveyance system to pass the peak hydraulic flows of the 100-year storm if it is located "on-line." The side slopes should be no steeper than 3:1 (H:V).

6) Roadside ditches should be regarded as significant potential swale/buffer strip sites and should be utilized for this purpose whenever possible. If flow is to be introduced through curb cuts, place pavement slightly above the elevation of the vegetated areas. Curb cuts should be at least 12 inches wide to prevent clogging.

7) Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses. If possible, divert runoff (other than necessary irrigation) during the period of vegetation

establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

Maintenance

The useful life of a vegetated swale system is directly proportional to its maintenance frequency. If properly designed and regularly maintained, vegetated swales can last indefinitely. The maintenance objectives for vegetated swale systems include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover.

Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages. Cuttings should be removed from the channel and disposed in a local composting facility. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. The application of fertilizers and pesticides should be minimal.

Another aspect of a good maintenance plan is repairing damaged areas within a channel. For example, if the channel develops ruts or holes, it should be repaired utilizing a suitable soil that is properly tamped and seeded. The grass cover should be thick; if it is not, reseed as necessary. Any standing water removed during the maintenance operation must be disposed to a sanitary sewer at an approved discharge location. Residuals (e.g., silt, grass cuttings) must be disposed in accordance with local or State requirements. Maintenance of grassed swales mostly involves maintenance of the grass or wetland plant cover. Typical maintenance activities are summarized below:

- Inspect swales at least twice annually for erosion, damage to vegetation, and sediment and debris accumulation preferably at the end of the wet season to schedule summer maintenance and before major fall runoff to be sure the swale is ready for winter. However, additional inspection after periods of heavy runoff is desirable. The swale should be checked for debris and litter, and areas of sediment accumulation.

- Grass height and mowing frequency may not have a large impact on pollutant removal. Consequently, mowing may only be necessary once or twice a year for safety or aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in swale areas, particularly along highways. The need for litter removal is determined through periodic inspection, but litter should always be removed prior to mowing.

- Sediment accumulating near culverts and in channels should be removed when it builds up to 75 mm (3 in.) at any spot, or covers vegetation.

- Regularly inspect swales for pools of standing water. Swales can become a nuisance due to mosquito breeding in standing water if obstructions develop (e.g. debris accumulation, invasive vegetation) and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available to estimate the difference in cost between various swale designs. One study (SWRPC, 1991) estimated the construction cost of grassed channels at approximately \$0.25 per ft^2. This price does not include design costs or contingencies. Brown and Schueler (1997) estimate these costs at approximately 32 percent of construction costs for most stormwater management practices. For swales, however, these costs would probably be significantly higher since the construction costs are so low compared with other practices. A more realistic estimate would be a total cost of approximately \$0.50 per ft^2, which compares favorably with other stormwater management practices.

Table 2 Swale Cost Estimate (SEWRPC, 1991)

Component	Unit	Extent	Unit Cost			Total Cost		
			Low	Moderate	High	Low	Moderate	High
Mobilization / Demobilization-Light	Swale	1	$107	$274	$441	$107	$274	$441
Site Preparation								
Clearing[b]	Acre	0.5	$2,200	$3,800	$5,400	$1,100	$1,900	$2,700
Grubbing[c]	Acre	0.25	$3,800	$5,200	$6,600	$950	$1,300	$1,650
General Excavation[d]	Yd^3	372	$2.10	$3.70	$5.30	$781	$1,376	$1,972
Level and Till[e]	Yd^2	1,210	$0.20	$0.35	$0.50	$242	$424	$605
Sites Development								
Salvaged Topsoil Seed, and Mulch[f]	Yd^2	1,210	$0.40	$1.00	$1.60	$484	$1,210	$1,936
Sod[g]	Yd^2	1,210	$1.20	$2.40	$3.60	$1,452	$2,904	$4,356
Subtotal	--	--	--	--	--	$5,116	$9,388	$13,680
Contingencies	Swale	1	25%	25%	25%	$1,279	$2,347	$3,415
Total	--	--	--	--	--	$6,395	$11,735	$17,075

Source: (SEWRPC, 1991)

Note: Mobilization/demobilization refers to the organization and planning involved in establishing a vegetative swale.

[a] Swale has a bottom width of 1.0 foot, a top width of 10 feet with 1:3 side slopes, and a 1,000-foot length.

[b] Area cleared = (top width + 10 feet) x swale length.

[c] Area grubbed = (top width x swale length).

[d] Volume excavated = (0.67 x top width x swale depth) x swale length (parabolic cross-section).

[e] Area tilled = $\left(\text{top width} + \frac{8(\text{swale depth}^2)}{3(\text{top width})}\right)$ x swale length (parabolic cross-section).

[f] Area seeded = area cleared x 0.5.

[g] Area sodded = area cleared x 0.5.

Table 3 Estimated Maintenance Costs (SEWRPC, 1991)

Component	Unit Cost	Swale Size (Depth and Top Width): 1.5 Foot Depth, One-Foot Bottom Width, 10-Foot Top Width	Swale Size (Depth and Top Width): 3-Foot Depth, 3-Foot Bottom Width, 21-Foot Top Width	Comment
Lawn Mowing	\$0.85 / 1,000 ft^2/ mowing	\$0.14 / linear foot	\$0.21 / linear foot	Lawn maintenance area=(top width + 10 feet) x length. Mow eight times per year
General Lawn Care	\$9.00 / 1,000 ft^2/ year	\$0.18 / linear foot	\$0.28 / linear foot	Lawn maintenance area = (top width + 10 feet) x length
Swale Debris and Litter Removal	\$0.10 / linear foot / year	\$0.10 / linear foot	\$0.10 / linear foot	–
Grass Reseeding with Mulch and Fertilizer	\$0.30 / yd^2	\$0.01 / linear foot	\$0.01 / linear foot	Area revegetated equals 1% of lawn maintenance area per year
Program Administration and Swale Inspection	\$0.15 / linear foot / year, plus \$25 / inspection	\$0.15 / linear foot	\$0.15 / linear foot	Inspect four times per year
Total	--	**\$0.58 / linear foot**	**\$ 0.75 / linear foot**	–

Maintenance Cost

Caltrans (2002) estimated the expected annual maintenance cost for a swale with a tributary area of approximately 2 ha at approximately $2,700. Since almost all maintenance consists of mowing, the cost is fundamentally a function of the mowing frequency. Unit costs developed by SEWRPC are shown in Table 3. In many cases vegetated channels would be used to convey runoff and would require periodic mowing as well, so there may be little additional cost for the water quality component. Since essentially all the activities are related to vegetation management, no special training is required for maintenance personnel.

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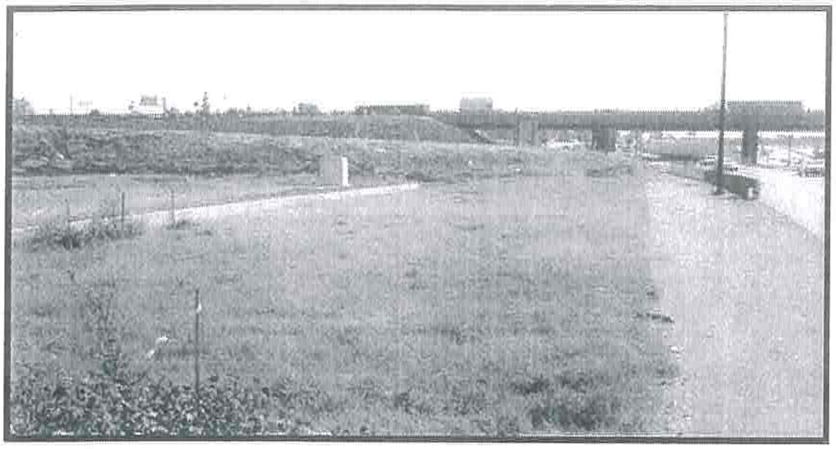
Vegetated Buffer Strip TC-31



Design Considerations

- Tributary Area
- Slope
- Water Availability
- Aesthetics

Description

Grassed buffer strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure. Consequently, there is little resistance to their use.

Targeted Constituents

✓	Sediment	■
✓	Nutrients	●
✓	Trash	▲
✓	Metals	■
✓	Bacteria	●
✓	Oil and Grease	■
✓	Organics	▲

Legend *(Removal Effectiveness)*

● Low ■ High

▲ Medium

California Experience

Caltrans constructed and monitored three vegetated buffer strips in southern California and is currently evaluating their performance at eight additional sites statewide. These strips were generally effective in reducing the volume and mass of pollutants in runoff. Even in the areas where the annual rainfall was only about 10 inches/yr, the vegetation did not require additional irrigation. One factor that strongly affected performance was the presence of large numbers of gophers at most of the southern California sites. The gophers created earthen mounds, destroyed vegetation, and generally reduced the effectiveness of the controls for TSS reduction.

Advantages

- Buffers require minimal maintenance activity (generally just erosion prevention and mowing).
- If properly designed, vegetated, and operated, buffer strips can provide reliable water quality benefits in conjunction with high aesthetic appeal.

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- Flow characteristics and vegetation type and density can be closely controlled to maximize BMP effectiveness.
- Roadside shoulders act as effective buffer strips when slope and length meet criteria described below.

Limitations

- May not be appropriate for industrial sites or locations where spills may occur.
- Buffer strips cannot treat a very large drainage area.
- A thick vegetative cover is needed for these practices to function properly.
- Buffer or vegetative filter length must be adequate and flow characteristics acceptable or water quality performance can be severely limited.
- Vegetative buffers may not provide treatment for dissolved constituents except to the extent that flows across the vegetated surface are infiltrated into the soil profile.
- This technology does not provide significant attenuation of the increased volume and flow rate of runoff during intense rain events.

Design and Sizing Guidelines

- Maximum length (in the direction of flow towards the buffer) of the tributary area should be 60 feet.
- Slopes should not exceed 15%.
- Minimum length (in direction of flow) is 15 feet.
- Width should be the same as the tributary area.
- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified. Vegetation whose growing season corresponds to the wet season is preferred.

Construction/Inspection Considerations

- Include directions in the specifications for use of appropriate fertilizer and soil amendments based on soil properties determined through testing and compared to the needs of the vegetation requirements.
- Install strips at the time of the year when there is a reasonable chance of successful establishment without irrigation; however, it is recognized that rainfall in a given year may not be sufficient and temporary irrigation may be required.
- If sod tiles must be used, they should be placed so that there are no gaps between the tiles; stagger the ends of the tiles to prevent the formation of channels along the strip.
- Use a roller on the sod to ensure that no air pockets form between the sod and the soil.

- Where seeds are used, erosion controls will be necessary to protect seeds for at least 75 days after the first rainfall of the season.

Performance

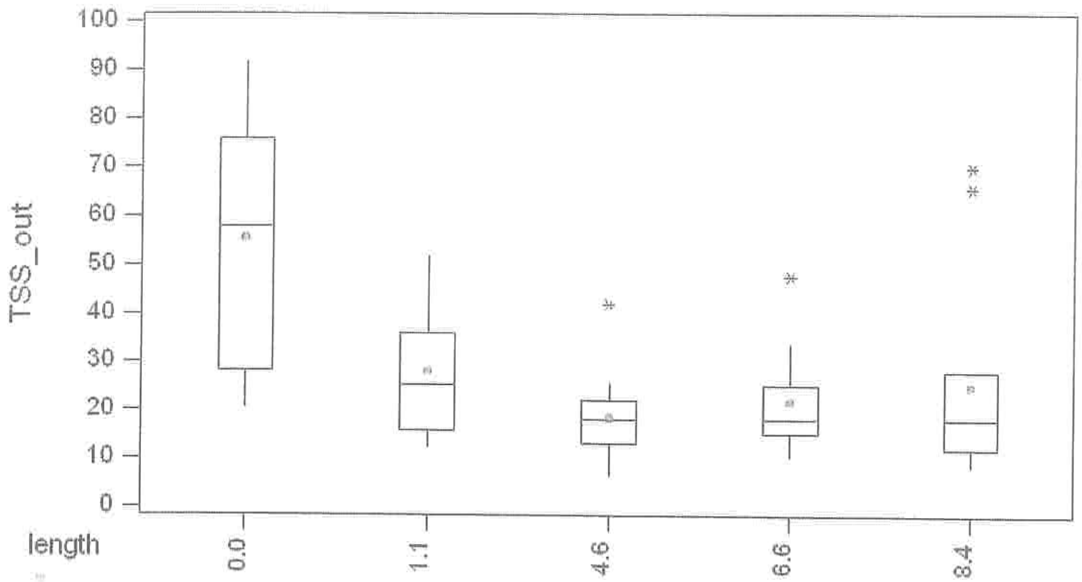
Vegetated buffer strips tend to provide somewhat better treatment of stormwater runoff than swales and have fewer tendencies for channelization or erosion. Table 1 documents the pollutant removal observed in a recent study by Caltrans (2002) based on three sites in southern California. The column labeled "Significance" is the probability that the mean influent and effluent EMCs are not significantly different based on an analysis of variance.

The removal of sediment and dissolved metals was comparable to that observed in much more complex controls. Reduction in nitrogen was not significant and all of the sites exported phosphorus for the entire study period. This may have been the result of using salt grass, a warm weather species that is dormant during the wet season, and which leaches phosphorus when dormant.

Another Caltrans study (unpublished) of vegetated highway shoulders as buffer strips also found substantial reductions often within a very short distance of the edge of pavement. Figure 1 presents a box and whisker plot of the concentrations of TSS in highway runoff after traveling various distances (shown in meters) through a vegetated filter strip with a slope of about 10%. One can see that the TSS median concentration reaches an irreducible minimum concentration of about 20 mg/L within 5 meters of the pavement edge.

Table 1. Pollutant Reduction in a Vegetated Buffer Strip

Constituent	Mean EMC		Removal %	Significance
	Influent (mg/L)	Effluent (mg/L)		P
TSS	119	31	74	<0.000
NO_3-N	0.67	0.58	13	0.367
TKN-N	2.50	2.10	16	0.542
Total N[a]	3.17	2.68	15	-
Dissolved P	0.15	0.46	[illegible]	0.047
Total P	0.42	0.62	[illegible]	0.035
Total Cu	0.058	0.009	84	<0.000
Total Pb	0.046	0.006	88	<0.000
Total Zn	0.245	0.055	78	<0.000
Dissolved Cu	0.029	0.007	77	0.004
Dissolved Pb	0.004	0.002	66	0.006
Dissolved Zn	0.099	0.035	65	<0.000



Filter strips also exhibit good removal of litter and other floatables because the water depth in these systems is well below the vegetation height and consequently these materials are not easily transported through them. Unfortunately little attenuation of peak runoff rates and volumes (particularly for larger events) is normally observed, depending on the soil properties. Therefore it may be prudent to follow the strips with another practice than can reduce flooding and channel erosion downstream.

Siting Criteria

The use of buffer strips is limited to gently sloping areas where the vegetative cover is robust and diffuse, and where shallow flow characteristics are possible. The practical water quality benefits can be effectively eliminated with the occurrence of significant erosion or when flow concentration occurs across the vegetated surface. Slopes should not exceed 15 percent or be less than 1 percent. The vegetative surface should extend across the full width of the area being drained. The upstream boundary of the filter should be located contiguous to the developed area. Use of a level spreading device (vegetated berm, sawtooth concrete border, rock trench, etc) to facilitate overland sheet flow is not normally recommended because of maintenance considerations and the potential for standing water.

Filter strips are applicable in most regions, but are restricted in some situations because they consume a large amount of space relative to other practices. Filter strips are best suited to treating runoff from roads and highways, roof downspouts, small parking lots, and pervious surfaces. They are also ideal components of the "outer zone" of a stream buffer or as pretreatment to a structural practice. In arid areas, however, the cost of irrigating the grass on the practice will most likely outweigh its water quality benefits, although aesthetic considerations may be sufficient to overcome this constraint. Filter strips are generally impractical in ultra-urban areas where little pervious surface exists.

Some cold water species, such as trout, are sensitive to changes in temperature. While some treatment practices, such as wet ponds, can warm stormwater substantially, filter strips do not are not expected to increase stormwater temperatures. Thus, these practices are good for protection of cold-water streams.

Filter strips should be separated from the ground water by between 2 and 4 ft to prevent contamination and to ensure that the filter strip does not remain wet between storms.

Additional Design Guidelines

Filter strips appear to be a minimal design practice because they are basically no more than a grassed slope. In general the slope of the strip should not exceed 15fc% and the strip should be at least 15 feet long to provide water quality treatment. Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion. The top of the strip should be installed 2-5 inches below the adjacent pavement, so that vegetation and sediment accumulation at the edge of the strip does not prevent runoff from entering.

A major question that remains unresolved is how large the drainage area to a strip can be. Research has conclusively demonstrated that these are effective on roadside shoulders, where the contributing area is about twice the buffer area. They have also been installed on the perimeter of large parking lots where they performed fairly effectively; however much lower slopes may be needed to provide adequate water quality treatment.

The filter area should be densely vegetated with a mix of erosion-resistant plant species that effectively bind the soil. Native or adapted grasses, shrubs, and trees are preferred because they generally require less fertilizer and are more drought resistant than exotic plants. Runoff flow velocities should not exceed about 1 fps across the vegetated surface.

For engineered vegetative strips, the facility surface should be graded flat prior to placement of vegetation. Initial establishment of vegetation requires attentive care including appropriate watering, fertilization, and prevention of excessive flow across the facility until vegetation completely covers the area and is well established. Use of a permanent irrigation system may help provide maximal water quality performance.

In cold climates, filter strips provide a convenient area for snow storage and treatment. If used for this purpose, vegetation in the filter strip should be salt-tolerant (e.g., creeping bentgrass), and a maintenance schedule should include the removal of sand built up at the bottom of the slope. In arid or semi-arid climates, designers should specify drought-tolerant grasses to minimize irrigation requirements.

Maintenance

Filter strips require mainly vegetation management; therefore little special training is needed for maintenance crews. Typical maintenance activities and frequencies include:

- Inspect strips at least twice annually for erosion or damage to vegetation, preferably at the end of the wet season to schedule summer maintenance and before major fall run-off to be sure the strip is ready for winter. However, additional inspection after periods of heavy run-off is most desirable. The strip should be checked for debris and litter and areas of sediment accumulation.

- Recent research on biofiltration swales, but likely applicable to strips (Colwell et al., 2000), indicates that grass height and mowing frequency have little impact on pollutant removal;

consequently, mowing may only be necessary once or twice a year for safety and aesthetics or to suppress weeds and woody vegetation.

- Trash tends to accumulate in strip areas, particularly along highways. The need for litter removal should be determined through periodic inspection but litter should always be removed prior to mowing.

- Regularly inspect vegetated buffer strips for pools of standing water. Vegetated buffer strips can become a nuisance due to mosquito breeding in level spreaders (unless designed to dewater completely in 48-72 hours), in pools of standing water if obstructions develop (e.g. debris accumulation, invasive vegetation), and/or if proper drainage slopes are not implemented and maintained.

Cost

Construction Cost

Little data is available on the actual construction costs of filter strips. One rough estimate can be the cost of seed or sod, which is approximately 30¢ per ft^2 for seed or 70¢ per ft^2 for sod. This amounts to between $13,000 and $30,000 per acre of filter strip. This cost is relatively high compared with other treatment practices. However, the grassed area used as a filter strip may have been seeded or sodded even if it were not used for treatment. In these cases, the only additional cost is the design. Typical maintenance costs are about $350/acre/year (adapted from SWRPC, 1991). This cost is relatively inexpensive and, again, might overlap with regular landscape maintenance costs.

The true cost of filter strips is the land they consume. In some situations this land is available as wasted space beyond back yards or adjacent to roadsides, but this practice is cost-prohibitive when land prices are high and land could be used for other purposes.

Maintenance Cost

Maintenance of vegetated buffer strips consists mainly of vegetation management (mowing, irrigation if needed, weeding) and litter removal. Consequently the costs are quite variable depending on the frequency of these activities and the local labor rate.

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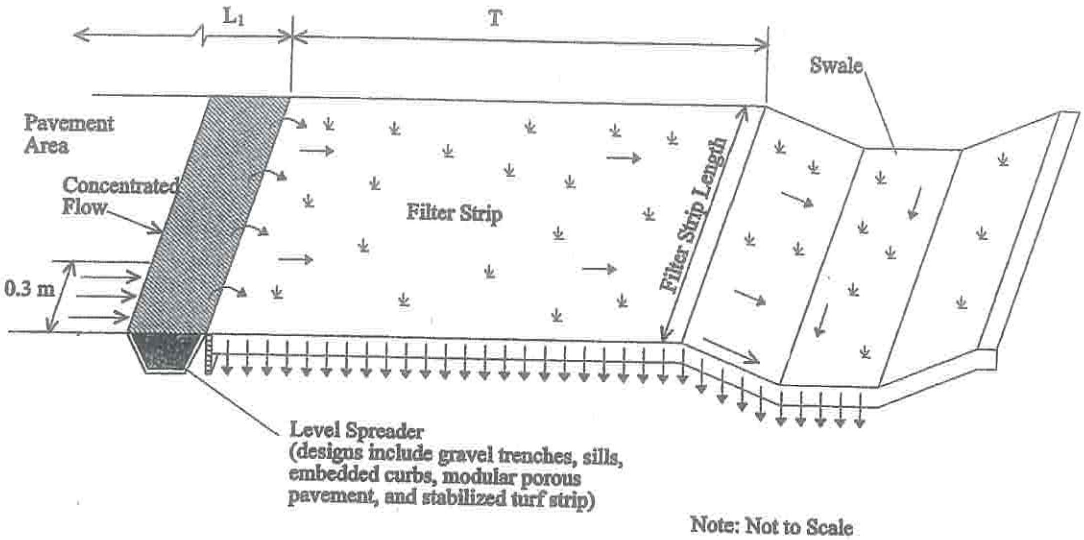
L1
T
Swale
Pavement Area
Concentrated Flow
Filter Strip
Filter Strip Length
0.3 m
Level Spreader (designs include gravel trenches, sills, embedded curbs, modular porous pavement, and stabilized turf strip)
Note: Not to Scale

Drain Inserts

Design Considerations

- Use with other BMPs
- Fit and Seal Capacity within Inlet

Description

Drain inserts are manufactured filters or fabric placed in a drop inlet to remove sediment and debris. There are a multitude of inserts of various shapes and configurations, typically falling into one of three different groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are one box; that is, the setting area and filtration through media occur in the same box. Some products consist of one or more trays or mesh grates. The trays may hold different types of media. Filtration media vary by manufacturer. Types include polypropylene, porous polymer, treated cellulose, and activated carbon.

California Experience

The number of installations is unknown but likely exceeds a thousand. Some users have reported that these systems require considerable maintenance to prevent plugging and bypass.

Advantages

- Does not require additional space as inserts as the drain inlets are already a component of the standard drainage systems.
- Easy access for inspection and maintenance.
- As there is no standing water, there is little concern for mosquito breeding.
- A relatively inexpensive retrofit option.

Limitations

Performance is likely significantly less than treatment systems that are located at the end of the drainage system such as ponds and vaults. Usually not suitable for large areas or areas with trash or leaves than can plug the insert.

Design and Sizing Guidelines

Refer to manufacturer's guidelines. Drain inserts come any many configurations but can be placed into three general groups: socks, boxes, and trays. The sock consists of a fabric, usually constructed of polypropylene. The fabric may be attached to a frame or the grate of the inlet holds the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene "bag" is placed in the wire mesh box. The bag takes the form of the box. Most box products are

Targeted Constituents

- ✓ Sediment
- ✓ Nutrients
- ✓ Trash
- ✓ Metals
- Bacteria
- ✓ Oil and Grease
- ✓ Organics

Removal Effectiveness

See New Development and Redevelopment Handbook-Section 5.

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one box; that is, the setting area and filtration through media occurs in the same box. One manufacturer has a double-box. Stormwater enters the first box where setting occurs. The stormwater flows into the second box where the filter media is located. Some products consist of one or more trays or mesh grates. The trays can hold different types of media. Filtration media vary with the manufacturer: types include polypropylene, porous polymer, treated cellulose, and activated carbon.

Construction/Inspection Considerations

Be certain that installation is done in a manner that makes certain that the stormwater enters the unit and does not leak around the perimeter. Leakage between the frame of the insert and the frame of the drain inlet can easily occur with vertical (drop) inlets.

Performance

Few products have performance data collected under field conditions.

Siting Criteria

It is recommended that inserts be used only for retrofit situations or as pretreatment where other treatment BMPs presented in this section area used.

Additional Design Guidelines

Follow guidelines provided by individual manufacturers.

Maintenance

Likely require frequent maintenance, on the order of several times per year.

Cost

- The initial cost of individual inserts ranges from less than $100 to about $2,000. The cost of using multiple units in curb inlet drains varies with the size of the inlet.
- The low cost of inserts may tend to favor the use of these systems over other, more effective treatment BMPs. However, the low cost of each unit may be offset by the number of units that are required, more frequent maintenance, and the shorter structural life (and therefore replacement).

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ATTACHMENT E

BMP TABLES

Table 3.1 Anticipated and Potential Pollutants Generated by Land Use Type

	General Pollutant Categories								
Priority Project Categories	Sediments	Nutrients	Heavy Metals	Organic Compounds	Trash & Debris	Oxygen Demanding Substances	Oil & Grease	Bacteria & Viruses	Pesticides
Detached Residential Development	X	X			X	X	X	X	X
Attached Residential Development	X	X			X	P(1)	P(2)	P	X
Commercial Development >100,000 ft^2	P(1)	P(1)		P(2)	X	P(5)	X	P(3)	P(5)
Automotive Repair Shop			X	X(4)(5)	X		X		
Restaurants					X	X	X	X	
Hillside Development >5,000 ft^2	X	X			X	X	X		X
Parking Lots	P(1)	P(1)	X		X	P(1)	X		P(1)
Streets, Highways & Freeways	X	P(1)	X	X(4)	X	P(5)	X		

X=anticipated
P=potential
(1) A potential pollutant if landscaping exists on site.
(2) A potential pollutant if the project includes uncovered parking areas.
(3) A potential pollutant if land use involves food or animal waste products.
(4) Including petroleum hydrocarbons.
(5) Including solvents.

Table 4.2 Standard Storm Water Selection Matrix

Priority Project Category	Site Design BMPs(1)	Source Control BMPs(2)	Requirements Applicable to Individual Priority Project Categories(3)										
			a. Private Roads	b. Residential Driveways & Guest Parking	c. Dock Areas	d. Maintenance Bays	e. Vehicle Wash Areas	f. Outdoor Processing Areas	g. Equipment Wash Area	h. Parking Areas	I. Roadways	j. Fueling Areas	k. Hillside Landscaping
Detached Residential Development	R	R	R	R									R
Attached Residential Development	R	R	R	R									R
Commercial Development >100,000 ft^2	R	R			R	R	R	R					
Automotive Repair Shop	R	R			R	R	R		R			R	
Restaurants	R	R			R				R				
Hillside Development >5,000 ft^2	R	R	R										R
Parking Lots	R	R								R(4)			
Streets, Highways & Freeways	R	R									R		

R = Required; select one or more applicable and appropriate BMPs from the steps in Section 4.1 & 4.2, or equivalent as identified in sections 4.6.1-4.6.3.
(1) Refer to Section 4.1.
(2) Refer to Section 4.2.
(3) Priority project categories must apply specific storm water BMP requirements, where applicable. Projects are subject to the requirements of all priority project categories that apply.
(4) Applies if the paved area totals >5,000 square feet or with >15 parking spaces and is potentially exposed to urban runoff.

Table 4.3 Treatment Control BMP Selection Matrix[1].

Pollutant of Concern	Treatment Control BMP Categories						
	Biofilters	Detention Basins	Infiltration Basins[2]	Wet Ponds or Wetlands	Drainage Inserts	Filtration	Hydrodynamic Separator Systems[3]
Sediment	M	H	H	H	L	H	M
Nutrients	L	M	M	M	L	M	L
Heavy Metals	M	M	M	H	L	H	L
Organic Compounds	U	U	U	M	L	M	L
Trash & Debris	L	H	U	H	M	H	M
Oxygen Demanding Substances	L	M	M	M	L	M	L
Bacteria	U	U	H	H	L	M	L
Oil & Grease	M	M	U	U	L	H	L
Pesticides	U	U	U	L	L	U	L

(1) Copermittees are encouraged to periodically assess the performance characteristics of many of these BMPs to update this table.
(2) Including trenches and porous pavement.
(3) Also known as hydrodynamic devices and baffle boxes.

L: Low removal efficiency.
M: Medium removal efficiency.
H: High removal efficiency.
U: Unknown removal efficiency.

Sources: *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (1993), *National Stormwater Best Management Practices Database* (2001), *Guide for BMP Selection in Urban Developed Areas* (2001), and *Caltrans New Technology Report* (2001).

ATTACHMENT F

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